until morning during the winter the watchman acts as fireman for the boilers to maintain the steam heat in the building. This diagram having previously been illustrated in the TRANSACTIONS of the INSTITUTE November 1895, it will not further be described here, except to state that the various lines shown on the diagram represent the loads of the different motors, elevators, etc., and the periods during which they operate. The writer hopes in the future to present to the INSTITUTE a new diagram representing the actual load lines of the plant, compiled from statistics covering its operation for a considerable length of time, and it will then be interesting to compare the actual diagram with this one which was prepared before starting to design the plant.

DISCUSSION.

MR. WOLCOTT:—I would like to ask Mr. Arnold whether it would be cheaper to use some gas now in that building or to use the battery a little more and dispense with the gas. He says some gas is used, as I understand him. I notice that there is a sudden drop in the load at 5:30 P. M. when the gas is turned on, and that allows the surplus current to go into the battery. If that gas were not used, the diagram would be of a considerably different shape.

MR. ARNOLD:—This diagram was prepared in my office before the method of re-constructing the plant was decided upon, and the various lines represent the different motors, elevators, etc., as we supposed they would operate in practice. The point marked "gas turned on" is the time they turn the gas on now,—not what it will be in operation, because we propose to turn the gas off entirely. This diagram was prepared over a year ago. In all probability, within six months from now I will be able to give you a diagram showing what the actual load line of the plant is.

MR. J. W. LIEB, JR:—I would like to ask Mr. Arnold why it is that in the plant he describes the peak of the load occurs between 11 A. M. and 1 P. M.

MR. ARNOLD:—That is the time when the people connected with the Chicago Board of Trade are most excited. The Board opens at 9.30 o'clock in the morning. At 12.30 they go to their offices and figure up what they have made or lost, consequently the office lights are used most at this time, and some of the motors shown running at this particular period are shut off at a later period, which also accounts for a part of the load.

MR. RIES:—I would like to ask Mr. Arnold to explain a little more fully the precise conditions under which—referring to Fig. 5—one steam engine is cut off and the other one is connected to the intermediate shaft to drive both dynamos. It would seem that this arrangement would not prove very practicable

under full loads, unless the engines are each capable of being worked to double their normal capacity, thereby requiring larger engines than would be employed in ordinary direct-driving installations. But, perhaps, Mr. Arnold may have special reasons for the construction illustrated. What is the object of that?

MR. ARNOLD:—That is a condition that sometimes arises. Suppose one engine and the generator attached to the other engine should become disabled, your plant would then be completely shut down if independent units were employed, unless you had a third unit to put in operation. Such a thing is liable to happen, and it is for this emergency that this arrangement is specially adapted, although there are other advantages.

MR. RIES:—Then my understanding of the matter is correct in assuming that each engine is only of sufficient power to operate *one* of the two dynamos at a time, and that it is only in case of the disablement of *one* of the engines *and* the *opposite* dynamo that the combination alluded to is supposed to be utilized.

MR. ARNOLD:—Suppose the battery should be out of service and one engine should become disabled. You would then be obliged to have the full capacity of both generators to operate the plant. The way these engines are designed and piped, you can double the capacity of either engine, and drive both generators to their full capacity from either engine, while the breakdown is in existence.

MR. RIES:—Isn't this construction somewhat complicated, as against the use of a separate engine and dynamo held as reserve?

MR. ARNOLD:—No, it is not complicated, costs very much less money than a third unit, and gives the same reliability.

MR. RIES:—Then the magnetic clutch, to which you referred. I suppose that it is intended to disconnect the disabled engine from the main shaft, leaving the internal shaft to drive both dynamos?

MR. ARNOLD:—Yes, sir.

MR. RIES:—And as to the magnetic clutch connecting the intermediate shaft?

MR. ARNOLD:—That is a double clutch whereby you can connect either generator to its corresponding engine, or you can also connect the interior shaft to either engine, or connect either generator to the interior shaft. It works both ways. I want to state that I do not wish too much stress to be put upon this magnetic clutch question at this time, because I have not yet developed it to a point where I am able to say what it will or will not do; but I thoroughly believe in such clutches, and am now engaged in developing a formula to build them by. The other mechanical connections are now in operation, and they are successful.

MR. RIES:—I simply wanted, Mr Chairman, to get a little further explanation as to the reasons for this peculiar construction.

MR. ARNOLD:—There are a number of advantages to this thing, which, as the plant increases in size, become apparent. I have not said anything about them in this paper. The paper

was prepared simply to show the general plan of the plant, and this arrangement being somewhat of a hobby of mine, I have mentioned it as little as possible, except enough to give the general idea of its make up.

MR. DOUGLASS BURNETT:—We are bound to admire the care which Mr. Arnold has bestowed upon all the details of this plant, and observing that a great deal of information is available, I desire to draw upon him for a little of it.

First,—as to any trouble he may have experienced with motor load; is not a large proportion of the output between 11 A. M. and 1 P. M. absorbed by motors, and does he find it desirable at that time to run separate engines for the two classes of service—lighting and power? Under those panicky conditions to which he refers, what is the maximum number of amperes which he might be called upon to supply?

The car mile consumption of his elevators has been given on page 273 as 4¼ K. W. hours. I very much wish that that number of K. W. hours could be translated into cents; in other words, what does current cost him per K. W. hour?

Finally, as to the load curve: How does this theoretical diagram work out in practice? Does it coincide substantially with one which would be obtained by observation? We presume that it was designed for a winter's day,—that is, maximum condition, and not for the average of an entire year. We trust that Mr. Arnold will enlighten us upon these points.

MR. ARNOLD:— The black line represents the total load of the plant on an ordinary day. The dotted line above represents the maximum load of the plant on a dark day. In other words, our Chicago weather is so uncertain that it very often happens that the sun may be shining, and suddenly a cloud will come up and darken the sky over the city, so that all the lights in the building will need to be turned on. It is under those conditions that the upper dotted line was prepared. In that case the plant would be at full load, but the surplus would have to come from the second generator or battery auxiliary. That is another case where the second generator would be run by the opposite engine. The average light day load is shown by the dotted line immediately under the heavy line; the other being the maximum or dark day load. Both engines and generators will handle the maximum day load conveniently. One generator and the battery auxiliary will handle the maximum load without difficulty.

I hope to be able to get the cost for fuel down to a sum not exceeding 1½ cents per K. W. hour. At some stations we are doing it at four-tenths of a cent per hour, where bituminous slack coal is worth ninety cents per ton. I think I will be able to show the INSTITUTE, in six months from now, a record of cost of coal per kilowatt hour of one cent from this plant. Under those conditions, four and a quarter cents per kilowatt hour means four and a quarter cents per car mile of travel on the elevators.

Adding to that the cost of labor, I think I will show you a record of running those elevators at a cost not exceeding eleven or twelve cents per car mile, whereas it is now costing eighteen to twenty cents per car mile for hydraulic elevators. In this connection I will state that I have tested a number of electric elevators in Chicago, for one of the large elevator corporations, and I find that the consumption of energy per car mile of travel varies from four to eleven kilowatt hours. I hope to be able to operate these cars at a cost of not over six cents per car mile for fuel alone. This is nothing but what anybody could do who would take these conditions and study them and make the most of everything available.

MR. BURNETT:—We thank Mr. Arnold very much. However, we wish he could state the actual maximum current required to run the elevators in that building. I should also like to ask if he can give us the total kilowatt hours generated during a year.

MR. ARNOLD:—I do not know that there is any hesitancy on my part in giving that information. The current taken by the two machines now in operation,—I mean the starting current, when starting a live load of 3000 pounds, together with the weight of the car,—reaches as high as 600 amperes at 125 volts. That is the service. It should be borne in mind, that the particular elevators there in use consume no current on the down trip; consequently the average consumption of current per car mile is low as compared with some elevators which consume current both going up and coming down, although not so high a starting current. The figures of $4\frac{1}{4}$ kilowatt hours per car mile are correct, because they are taken from a wattmeter which has been running now for four months. Indeed, that is the only figure that I felt absolutely safe in giving regarding the operation of the plant at present.

MR. LIEB:—I am sure that we all appreciate the careful preparation of Mr. Arnold's paper. I can only express the hope that when the plant has been in operation a sufficiently long time, Mr. Arnold may keep his promise and give us in some detail the operating costs. The question of the cost of current production in a plant of this character is an important one, and there is a great lack of reliable information sufficiently detailed to be of use in making comparisons. Usually many of the important items of cost are left out of consideration, and, if Mr. Arnold will permit me, I would suggest that in making up his analysis for future presentation to the INSTITUTE, he might with advantage follow the lines of some of the blanks used for that purpose by the large illuminating companies, which give the items of cost under appropriate heads. I think such a paper would be a valuable contribution, and the discussion would bring out important and interesting data. There are not many plants of the size of the one described by Mr. Arnold, operated as an isolated, plant and which have such a combination of elevator load, lighting load, and motor load. The arrangement of gener-

ating machinery, which he has adopted in his installation, would give valuable data for comparison, and for my part I hope that Mr. Arnold will fulfill his promise, and in due course of time present to the INSTITUTE details of operating cost.

MR. RIES:—It strikes me that the most valuable feature, probably, of Mr. Arnold's proposed installation is the extended use which he makes of secondary batteries in connection with the dynamo. Some years ago, I had occasion to devise a system somewhat analogous to this, for railway work, and from the revived interest which has been manifested of late in the secondary battery, I think it will be but a short time before the battery is very largely used both in stationary service and in railway installation. I notice, on referring to the diagram, Fig. 6, that the battery is very largely drawn upon between 11 and 1 o'clock in the day time, and between 11 o'clock at night and 7 o'clock in the morning. This would indicate from the abruptness of the lines that the battery is switched onto the service mains independently of the dynamos. But I would like to ask Mr. Arnold whether he also uses the battery as a regulator to render the load on the dynamo continuous or practically uniform while the dynamo is running and supplying these various forms of service?

MR. ARNOLD:—I use two regulators, one a hand regulator, and the other an automatic regulator. The hand regulator is adjusted by the engineer at a proper point, so that a certain number of the cells are used in parallel with the elevators; or, rather, so that the total voltage of whatever cells are used in parallel with the elevator is just enough less than the voltage of the dynamos to allow the cells to receive a constant charge, except when the maximum pull comes on the elevators. At all other times the batteries are in parallel and are receiving a charge. Then the regulated cells are charged by means of the generator end of the motor-generator, and the entire series of cells is charged by means of the generator end of the booster running in series with the main dynamo.

MR. RIES:—The batteries are in parallel with the dynamos, and in case of any sudden fluctuation of load, the batteries supply the deficiency?

MR. ARNOLD:—Yes, sir.

[At this point the President resumed the Chair.]

THE PRESIDENT:—Gentlemen, is there any further business to bring before the meeting?

THE SECRETARY:—We have an invitation from Mr. George Hill to visit the plant of the American Book Company on University Place. We also have an invitation from the Crocker-Wheeler Electric Company to visit their works. Both have already been announced.

On motion, the thanks of the INSTITUTE were tendered to the National Electrical Exposition Company for the privilege of occupying their convention hall, and for courtesies extended.

[Adjourned.]